
DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] this invention relates to the equipment which detects the rotational frequency of the body of revolution supported by the magnetic bearing in the state of magnetic levitation.
[0002]
[Description of the Prior Art] In order to perform the roll control of body of revolution in which non-contact support was carried out by the magnetic bearing, it is necessary to detect the rotational frequency of body of revolution. For example, with the conventional rotational frequency detection equipment indicated by JP,2-287263,A, the target section which becomes the end of body of revolution from a conductive material is prepared, and two crevices whose level differences are about 0.5mm are formed in the end face or the periphery side with phase contrast 180 degrees at the hand of cut. And an end face and periphery side including the crevice concerned are countered, and the rotation sensor of an eddy current formula is arranged. The output of the rotation sensor of this eddy current formula changes according to distance with a conductive material. Therefore, a rotation sensor detects a crevice according to the difference of distance, and outputs a pulse train-like signal. And the rotational frequency of body of revolution is detected by counting the pulse number in the predetermined time in this signal. In addition, in the steady state which body of revolution is rotating at the predetermined rotational frequency, position control of the body of revolution is correctly carried out by the magnetic bearing. Therefore, the distance of a rotation sensor and a conductive material will be abbreviation regularity if the change based on existence of a crevice is removed. When stopping body of revolution, body of revolution is slowed down with a roll control, and when it is admited that the rotational frequency was set to 0, the magnetic levitation of body of revolution is stopped. Thereby, body of revolution lands on touchdown bearing, and is held.
[0003]
[Problem(s) to be Solved by the Invention] In the above conventional rotational frequency detection equipments, when body of revolution vibrates in the axial direction or the direction of a radial according to unexpected causes (poor position control or earthquake) during slowdown operation of body of revolution, the distance of a rotation sensor and a conductive material is changed. This becomes the factor which makes the output of a rotation sensor produce change in addition to the existence of a crevice. Consequently, even if rotation of body of revolution stops, vibration of body of revolution becomes a cause and the output of a rotation sensor changes succeedingly. The control section of a magnetic bearing takes this change for the change based on the existence of a crevice, and it is judged that body of revolution is still under rotation. Therefore, the magnetic-levitation state of body of revolution is not canceled. For this reason, vibration does not decline easily but there is un-arranging [that vibration continues over a long time].
[0004] this invention aims at offering the rotational frequency detection equipment of the magnetic-levitation body of revolution which can grasp the rotation state of body of revolution correctly in view

of the above conventional troubles.
[0005]
[Means for Solving the Problem] The rotational frequency detection equipment of the magnetic-levitation body of revolution of this invention A rotation detection means to have the sensor section which countered with the body of revolution supported by the magnetic bearing in the state of magnetic levitation, and has been arranged, and to put and output the signal according to the rotational frequency of this body of revolution to the signal according to the distance of this body of revolution and the aforementioned sensor section, the variation rate which has the sensor section which countered the aforementioned body of revolution and has been arranged, and outputs the signal according to the variation rate of the body of revolution concerned -- a detection means and the above -- a variation rate -- by the output signal of a detection means the shaft which cancels the signal according to the aforementioned distance of the output signals of the aforementioned rotation detection means -- a variation rate -- a cancellation means and the aforementioned shaft -- a variation rate -- it has a signal-processing means to detect the rotational frequency of the aforementioned body of revolution based on the output signal of a cancellation means (claim 1) Thus, with the rotational frequency detection equipment of the constituted magnetic-levitation body of revolution, when body of revolution vibrates, while the variation rate by vibration is detected by the displacement detection means, the influence of vibration is included also in the output signal of a rotation detection means. however, a shaft -- a variation rate -- a cancellation means -- setting -- the above -- a variation rate -- the influence of vibration is removed by canceling the signal according to the aforementioned distance of the output signals of the aforementioned rotation detection means by the output signal of a detection means Therefore, even if vibration arises, only the signal of a rotational frequency is extracted, and a rotational frequency is detected by the signal-processing means.
[0006] the above-mentioned rotational frequency detection equipment -- setting -- a variation rate -- the radial in which two or more sensor sections of a detection means were prepared -- a variation rate -- one of sensors -- it is -- the sensor section of a rotation detection means -- the one radial concerned -- a variation rate -- you may be the rotation sensor arranged by approaching a sensor (claim 2) in this case -- if body of revolution produces vibration in the direction of a radial -- the one radial concerned -- a variation rate -- the influence of the variation rate by vibration reaches similarly to a sensor and a rotation sensor Therefore, the influence of vibration is certainly removed by canceling the signal according to the aforementioned distance of the output signals of a rotation detection means by the output signal of a displacement detection means.
[0007]
[Embodiments of the Invention] Drawing 1 is the block diagram showing the rotational frequency detection equipment of the magnetic-levitation body of revolution by 1 operation gestalt of this invention. In drawing, the body of revolution 2 of magnetic bearing equipment 1 is equipped with the main shaft section 21 and the bucket section 22. Moreover, the main shaft section 21 is equipped with the Rota section 23 in the center of the upper part, and equips the lower part with the disk section 24 and the target section 25. The Rota section 23 constitutes the motor (RF motor) 4 with the stator 3. Around [by the side of the upper part of a stator 3, and the lower part] the main shaft section 21, the radial magnetic bearing 5 which carries out non-contact support of the body of revolution 2 in the direction of a radial is arranged. Moreover, as the disk section 24 is inserted from the shaft orientations, the axial magnetic bearing 6 which carries out non-contact support of the body of revolution 2 in the axial direction is arranged. In addition, although not illustrated, the touchdown bearing which carries out contact support of the body of revolution 2 at the time of a magnetic-levitation halt is prepared in two shaft-orientations upper and lower sides of the main shaft section 21.
[0008] Radial displacement sensor 7R [two or more (eight pieces)] which detects the variation rate to the direction of a radial of body of revolution 2 is prepared in the hoop direction every 90 degrees in two shaft-orientations upper and lower sides of the main shaft section 21. Moreover, rotation sensor 8R counters the main shaft section 21 from a radial, and is arranged one piece. The output changes according to distance with the main shaft section 21 which counters, and rotation sensor 8R detects the

detecting element-ed (for example, crevice) formed in the periphery side of the main shaft section 21 according to the difference of distance, and outputs a pulse-like signal with the period according to the rotational frequency of body of revolution 2. this rotation sensor 8R -- from the axis-of-rotation heart of body of revolution 2 -- seeing -- two or more radials -- a variation rate -- the same direction of a radial as one in sensor 7R, and abbreviation -- it is arranged at the same distance, and shaft orientations are also approached mutually and it is arranged

[0009] Drawing 2 is the elements on larger scale showing the physical relationship of the main shaft section 21, and radial displacement sensor 7R and rotation sensor 8R which countered this and have been arranged. As shown in drawing, only rotation sensor 8R has countered the periphery side containing detecting-element-ed 21a, and radial displacement sensor 7R has countered the periphery side of the diameter of said which does not contain detecting-element-ed 21a. Therefore, although radial displacement sensor 7R is not influenced of detecting-element-ed 21a, when the main shaft section 21 produces a variation rate in the direction of a radial, the influence will attain to radial displacement sensor 7R and rotation sensor 8R equally.

[0010] On the other hand, in drawing 1 , the shaft-orientations soffit side of the target section 25 is countered, and one axial displacement-sensor 7A which detects the variation rate to the axial direction of body of revolution 2 is arranged. Moreover, rotation sensor 8A counters near the soffit side periphery of the target section 25, and is arranged one piece. The output changes according to distance with the target section 25 which counters, and rotation sensor 8A detects the detecting element-ed (for example, crevice) formed near the soffit side periphery of the target section 25 according to the difference of distance, and outputs a pulse-like signal with the period according to the rotational frequency of body of revolution 2. this rotation sensor 8A -- a gap with the soffit side of the target section 25 -- axial displacement-sensor 7A and abbreviation -- it is arranged so that it may become the same

[0011] (a) of drawing 3 is the elements on larger scale showing the physical relationship of the target section 25, and axial displacement-sensor 7A and rotation sensor 8A which countered this and have been arranged, and (b) is the bottom plan view of the target section 25. As shown in drawing, only rotation sensor 8A has countered the end face near the periphery containing detecting-element-ed 25a, and axial displacement-sensor 7A has countered the core which does not contain detecting-element-ed 25a. Therefore, although axial displacement-sensor 7A is not influenced of detecting-element-ed 25a, when the target section 25 produces a variation rate in the axial direction, the influence will attain to axial displacement-sensor 7A and rotation sensor 8A equally.

[0012] It returns to drawing 1 , and after each output of above-mentioned radial displacement sensor 7R and axial displacement-sensor 7A receives predetermined processings, such as A/D conversion, it is sent to DSP (it operates by the Digital Signal Processor:software program and is digital-signal-processing equipment in which high-speed real-time processing is possible)12 (however, since these circuit connection composition is known matters, it omits illustration.). Moreover, the radial magnetic bearing 5 and the axial magnetic bearing 6 are connected with DSP12 through the drive circuit which is not illustrated. Furthermore, the motor 4 is connected with DSP12 through the inverter which is not illustrated.

[0013] On the other hand, as shown in drawing 1 , radial displacement sensor 7R arranged by approaching rotation sensor 8R among two or more radial displacement sensor 7R and axial displacement-sensor 7A are connected with the displacement-sensor circuit 9. The displacement-sensor circuit 9 is equipped with the amplifier which processes separately the signal from these two displacement sensors 7R and 7A. Moreover, the rotation sensors 8R and 8A are connected with the rotation sensor circuit 10. The rotation sensor circuit 10 is equipped with the amplifier which processes separately the signal from these two rotation sensors 8R and 8A. Here, radial displacement sensor 7R, axial displacement-sensor 7A, and the displacement-sensor circuit 9 constitute a "displacement detection means" to output the signal according to the variation rate of body of revolution 2. Moreover, the rotation sensors 8R and 8A and the rotation sensor circuit 10 constitute a "rotation detection means" to put and output the signal according to the rotational frequency of body of revolution 2 to the signal according to opposite distance with body of revolution 2, like the after-mentioned.

[0014] the signal level to which body of revolution 2 is a magnetic-levitation quiescent state, and rotation sensor 8R outputs the amplification factor of each amplifier in the above-mentioned displacement-sensor circuit 9 and the rotation sensor circuit 10 in the state where rotation sensor 8R has not countered detecting-element-ed 21a -- a radial -- a variation rate -- the signal level which sensor 7R outputs, and a phase -- it is set up so that it may become equal Moreover, it is set up so that body of revolution 2 is a magnetic-levitation quiescent state, and the signal level which rotation sensor 8A outputs may spread signal level, a phase, etc. which axial displacement-sensor 7A outputs and it may become similarly in the state where rotation sensor 8A has not countered detecting-element-ed 25a. the above-mentioned displacement-sensor circuit 9 and the rotation sensor circuit 10 -- a shaft -- a variation rate -- it connects with the cancellation circuit 11 This axial displacement cancellation circuit 11 is equipped with the differential amplifier, high pass filter (high-pass filter), the comparator, the A/D converter, etc. The digital signal which this axial displacement cancellation circuit 11 outputs is inputted into DSP12.

[0015] In the magnetic bearing equipment 1 constituted as mentioned above, the body of revolution 2 supported by the radial magnetic bearing 5 and the axial magnetic bearing 6 in the state of magnetic levitation is rotated by the motor 4 at high speed. The position control of the body of revolution 2 under rotation detects the variation rate to the direction of a radial of body of revolution 2, and the variation rate to the axial direction by radial displacement sensor 7R and axial displacement-sensor 7A, respectively, and based on this detection result, when DSP12 controls the electromagnet of the radial magnetic bearing 5 and the axial magnetic bearing 6, it is performed.

[0016] On the other hand, the roll control of body of revolution 2 detects the rotational frequency of body of revolution 2 by rotation sensor 8R or 8A, and based on this detection result, when DSP12 controls the frequency of the power supplied to a motor 4, it is performed. It explains in more detail about detection operation of this rotational frequency. In addition, since there is no difference in the direction of a radial, and the axial direction about the following explanation of operation, although the direction of a radial is explained, it is completely the same also about the axial direction.

[0017] In the steady state in which non-contact support is carried out by the radial magnetic bearing 5 and the axial magnetic bearing 6, and body of revolution 2 is carrying out high-speed rotation in the state of magnetic levitation by them, position control of the body of revolution 2 is carried out correctly. At this time, the output of the displacement-sensor circuit 9 based on radial displacement sensor 7R serves as an output level of the abbreviation regularity shown in (a) of drawing 4 . On the other hand, based on the output level of (a), whenever the output ((b) of drawing 4) of the rotation sensor circuit 10 based on rotation sensor 8R detects detecting-element-ed 21a, it becomes that in which the pulse-like wave appeared. (a) and the output of (b) -- a shaft -- a variation rate -- a differential amplifier is carried out by the differential amplifier in the cancellation circuit 11 Therefore, the output of the differential amplifier serves as a wave shown in (c). Moreover, although the output level shown in (a) changes when body of revolution 2 produces a variation rate in the direction of a radial (it shifts in the vertical direction), the same change as this appears also in the wave of (b). therefore, a changed part -- a shaft -- a variation rate -- it is canceled by the differential amplifier in the cancellation circuit 11, and the wave of (c) does not change

[0018] On the other hand, when vibration occurs in body of revolution 2 according to poor position control, an earthquake, etc. during the slowdown for stopping body of revolution 2, the distance of radial displacement sensor 7R and the main shaft section 21 which counters this is changed continuously. Therefore, the output wave of the displacement-sensor circuit 9 based on radial displacement sensor 7R comes (a dotted line is an output before oscillating generating.) to be shown in (a) of drawing 5 . In order that the influence of the above-mentioned vibration may reach also like rotation sensor 8R, as the output of the rotation sensor circuit 10 based on rotation sensor 8R is shown in (b) of drawing 5 , the wave of the shape of a pulse train shown by the dotted line turns into a wave which rode on the wave of vibration. However, in order that the differential amplifier of the axial displacement cancellation circuit 11 may perform the differential amplifier of the output shown in (a) and (b), the influence of vibration is canceled and the output wave of the differential amplifier shown in (c) is acquired. This is the same as

the wave of (c) of drawing 4 .
[0019] Next, the output of the differential amplifier which has the wave shown in (c) of drawing 4 or (c) of drawing 5 is made a sharp output wave by HPF (refer to (a) of drawing 6), and is further made a rectangular pulse shape through a comparator (refer to (b) of drawing 6). A rectangular pulse shape is sent to DSP12, and the rotational frequency of body of revolution 2 is called for from the pulse number (or pulse period) counted in the predetermined time. DSP12 can be carried out in this way, and cannot be concerned with the existence of oscillating generating, but can count a pulse correctly, and can ask for a rotational frequency. Therefore, the roll control based on the detected rotational frequency can be performed correctly. Moreover, after oscillating generating, if body of revolution 2 stops, a pulse will no longer be outputted and only the output change ((a) of drawing 5) under the influence of vibration will be outputted from the displacement-sensor circuit 9 and the rotation sensor circuit 10. Therefore, the output of the differential amplifier in the axial displacement cancellation circuit 11 is set to about 0, and a pulse is no longer outputted to the axial displacement cancellation circuit 11 shell DSP 12. Therefore, DSP12 judges that body of revolution 2 stopped, stops magnetic levitation, and makes body of revolution 2 touch down. Thereby, vibration of body of revolution 2 declines and disappears at a stretch.

[0020] In addition, in the above-mentioned operation gestalt, the surfacing position in the axial direction of body of revolution 2 can be arbitrarily adjusted within the gap between up-and-down axial magnetic bearings by controlling the magnetism of the axial magnetic bearing 6 individually. Therefore, the variation rate of body of revolution 2 and vibration may be concerned, and the opposite distance of axial displacement-sensor 7A and the target section 25 may change that there is nothing. since [however,] the distance of rotation sensor 8A and the target section 25 changes similarly by this case -- a shaft -- a variation rate -- a part for the above-mentioned change is canceled by the differential amplifier in the cancellation circuit 11, and the signal of the wave shown in (c) of drawing 4 is outputted Therefore, the rotational frequency of body of revolution 2 can be grasped correctly, choosing the surfacing position of body of revolution 2 arbitrarily.
[0021] Moreover, although the rotational frequency was detected on the both sides of the direction of a radial, and the axial direction in the above-mentioned operation gestalt, only either is. furthermore, the shaft in the above-mentioned operation gestalt -- a variation rate -- although the cancellation circuit 11 processes analogically and outputs in digital one, if it is made to output a digital signal in the displacement-sensor circuit 9 and the rotation sensor circuit 10 of the preceding paragraph -- a shaft -- a variation rate -- it is also possible to perform the function of the cancellation circuit 11 within DSP12
[0022]
[Effect of the Invention] this invention constituted as mentioned above does the following effects so. Since according to the rotational frequency detection equipment of the magnetic-levitation body of revolution of a claim 1 the influence of vibration is removed by canceling the signal according to the distance of the output signals of a rotation detection means by the output signal of a displacement detection means even when body of revolution vibrates, even if vibration arises, only the signal of a rotational frequency is extracted. Therefore, the rotational frequency and rotation idle state of body of revolution can be correctly grasped by the signal-processing means.
[0023] if body of revolution produces vibration in the direction of a radial according to the rotational frequency detection equipment of the magnetic-levitation body of revolution of a claim 2 -- the one radial concerned -- a variation rate -- since the influence of the variation rate by vibration reaches similarly to a sensor and a rotation sensor -- a variation rate -- the influence of vibration is certainly removed by canceling the signal according to the distance of the output signals of a rotation detection means by the output signal of a detection means Therefore, the rotation state of body of revolution can always be correctly grasped by the signal-processing means.

[Translation done.]

* NOTICES *

Japan Patent Office is not responsible for any damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

MEANS

[Means for Solving the Problem] The rotational frequency detection equipment of the magnetic-levitation body of revolution of this invention A rotation detection means to have the sensor section which countered with the body of revolution supported by the magnetic bearing in the state of magnetic levitation, and has been arranged, and to put and output the signal according to the rotational frequency of this body of revolution to the signal according to the distance of this body of revolution and the aforementioned sensor section, the variation rate which has the sensor section which countered the aforementioned body of revolution and has been arranged, and outputs the signal according to the variation rate of the body of revolution concerned -- a detection means and the above -- a variation rate -- by the output signal of a detection means the shaft which cancels the signal according to the aforementioned distance of the output signals of the aforementioned rotation detection means -- a variation rate -- a cancellation means and the aforementioned shaft -- a variation rate -- it has a signal-processing means to detect the rotational frequency of the aforementioned body of revolution based on the output signal of a cancellation means (claim 1) Thus, with the rotational frequency detection equipment of the constituted magnetic-levitation body of revolution, when body of revolution vibrates, while the variation rate by vibration is detected by the displacement detection means, the influence of vibration is included also in the output signal of a rotation detection means. however, a shaft -- a variation rate -- a cancellation means -- setting -- the above -- a variation rate -- the influence of vibration is removed by canceling the signal according to the aforementioned distance of the output signals of the aforementioned rotation detection means by the output signal of a detection means Therefore, even if vibration arises, only the signal of a rotational frequency is extracted, and a rotational frequency is detected by the signal-processing means.
[0006] the above-mentioned rotational frequency detection equipment -- setting -- a variation rate -- the radial in which two or more sensor sections of a detection means were prepared -- a variation rate -- one of sensors -- it is -- the sensor section of a rotation detection means -- the one radial concerned -- a variation rate -- you may be the rotation sensor arranged by approaching a sensor (claim 2) in this case -- if body of revolution produces vibration in the direction of a radial -- the one radial concerned -- a variation rate -- the influence of the variation rate by vibration reaches similarly to a sensor and a rotation sensor Therefore, the influence of vibration is certainly removed by canceling the signal according to the aforementioned distance of the output signals of a rotation detection means by the output signal of a displacement detection means.
[0007]
[Embodiments of the Invention] Drawing 1 is the block diagram showing the rotational frequency detection equipment of the magnetic-levitation body of revolution by 1 operation gestalt of this invention. In drawing, the body of revolution 2 of magnetic bearing equipment 1 is equipped with the main shaft section 21 and the bucket section 22. Moreover, the main shaft section 21 is equipped with the Rota section 23 in the center of the upper part, and equips the lower part with the disk section 24 and the target section 25. The Rota section 23 constitutes the motor (RF motor) 4 with the stator 3. Around [by the side of the upper part of a stator 3, and the lower part] the main shaft section 21, the radial

magnetic bearing 5 which carries out non-contact support of the body of revolution 2 in the direction of a radial is arranged. Moreover, as the disk section 24 is inserted from the shaft orientations, the axial magnetic bearing 6 which carries out non-contact support of the body of revolution 2 in the axial direction is arranged. In addition, although not illustrated, the touchdown bearing which carries out contact support of the body of revolution 2 at the time of a magnetic-levitation halt is prepared in two shaft-orientations upper and lower sides of the main shaft section 21.

[0008] Radial displacement sensor 7R [two or more (eight pieces)] which detects the variation rate to the direction of a radial of body of revolution 2 is prepared in the hoop direction every 90 degrees in two shaft-orientations upper and lower sides of the main shaft section 21. Moreover, rotation sensor 8R counters the main shaft section 21 from a radial, and is arranged one piece. The output changes according to distance with the main shaft section 21 which counters, and rotation sensor 8R detects the detecting element-ed (for example, crevice) formed in the periphery side of the main shaft section 21 according to the difference of distance, and outputs a pulse-like signal with the period according to the rotational frequency of body of revolution 2. this rotation sensor 8R -- from the axis-of-rotation heart of body of revolution 2 -- seeing -- two or more radials -- a variation rate -- the same direction of a radial as one in sensor 7R, and abbreviation -- it is arranged at the same distance, and shaft orientations are also approached mutually and it is arranged

[0009] Drawing 2 is the elements on larger scale showing the physical relationship of the main shaft section 21, and radial displacement sensor 7R and rotation sensor 8R which countered this and have been arranged. As shown in drawing, only rotation sensor 8R has countered the periphery side containing detecting-element-ed 21a, and radial displacement sensor 7R has countered the periphery side of the diameter of said which does not contain detecting-element-ed 21a. Therefore, although radial displacement sensor 7R is not influenced of detecting-element-ed 21a, when the main shaft section 21 produces a variation rate in the direction of a radial, the influence will attain to radial displacement sensor 7R and rotation sensor 8R equally.

[0010] On the other hand, in drawing 1 , the shaft-orientations soffit side of the target section 25 is countered, and one axial displacement-sensor 7A which detects the variation rate to the axial direction of body of revolution 2 is arranged. Moreover, rotation sensor 8A counters near the soffit side periphery of the target section 25, and is arranged one piece. The output changes according to distance with the target section 25 which counters, and rotation sensor 8A detects the detecting element-ed (for example, crevice) formed near the soffit side periphery of the target section 25 according to the difference of distance, and outputs a pulse-like signal with the period according to the rotational frequency of body of revolution 2. this rotation sensor 8A -- a gap with the soffit side of the target section 25 -- axial displacement-sensor 7A and abbreviation -- it is arranged so that it may become the same

[0011] (a) of drawing 3 is the elements on larger scale showing the physical relationship of the target section 25, and axial displacement-sensor 7A and rotation sensor 8A which countered this and have been arranged, and (b) is the bottom plan view of the target section 25. As shown in drawing, only rotation sensor 8A has countered the end face near the periphery containing detecting-element-ed 25a, and axial displacement-sensor 7A has countered the core which does not contain detecting-element-ed 25a. Therefore, although axial displacement-sensor 7A is not influenced of detecting-element-ed 25a, when the target section 25 produces a variation rate in the axial direction, the influence will attain to axial displacement-sensor 7A and rotation sensor 8A equally.

[0012] It returns to drawing 1 , and after each output of above-mentioned radial displacement sensor 7R and axial displacement-sensor 7A receives predetermined processings, such as A/D conversion, it is sent to DSP (it operates by the Digital Signal Processor:software program and is digital-signal-processing equipment in which high-speed real-time processing is possible)12 (however, since these circuit connection composition is known matters, it omits illustration.). Moreover, the radial magnetic bearing 5 and the axial magnetic bearing 6 are connected with DSP12 through the drive circuit which is not illustrated. Furthermore, the motor 4 is connected with DSP12 through the inverter which is not illustrated.

[0013] On the other hand, as shown in drawing 1 , radial displacement sensor 7R arranged by

approaching rotation sensor 8R among two or more radial displacement sensor 7R and axial displacement-sensor 7A are connected with the displacement-sensor circuit 9. The displacement-sensor circuit 9 is equipped with the amplifier which processes separately the signal from these two displacement sensors 7R and 7A. Moreover, the rotation sensors 8R and 8A are connected with the rotation sensor circuit 10. The rotation sensor circuit 10 is equipped with the amplifier which processes separately the signal from these two rotation sensors 8R and 8A. Here, radial displacement sensor 7R, axial displacement-sensor 7A, and the displacement-sensor circuit 9 output the signal according to the variation rate of body of revolution 2.

[Translation done.]